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PASSIVE ARM RESTRAINT CURTAIN (PARC) FOR NAVY AIRCRAFT  
EJECTION SEATS(U) NAVAL AIR DEVELOPMENT CENTER  
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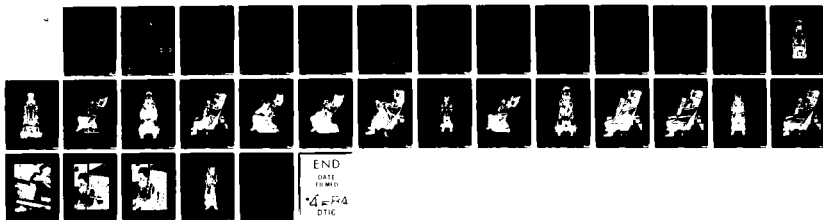
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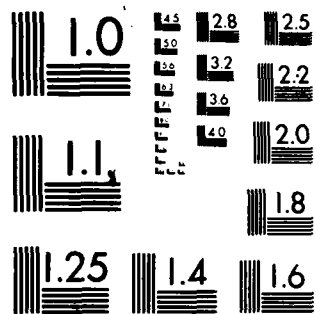
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REPORT NO. NADC-83138-60

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# PASSIVE ARM RESTRAINT CURTAIN (PARC) FOR NAVY AIRCRAFT EJECTION SEATS

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Warminster, Pennsylvania 18974

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  In an effort related to reducing arm flail injuries due to ejection windblast, the Navy is evaluating a "passive" arm restraint system for retrofit on Navy aircraft ejection seats. The term "passive" implies that the system will operate without the crewmember having to perform tasks other than what he currently performs (in a seat without an arm restraint system) to ready himself for flight. The Passive Arm Restraint Curtain (PARC) is designed to not only prevent arm flail but also to be cost effective and easily retrofitted. Prototypes have been fabricated and attached to current Navy ejection seats where they have		

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ABSTRACT (Continued)

been subjected to function feasibility testing and human factors evaluations. Preliminary results show the PARC to be a viable approach for providing passive arm restraint, but more development and testing is required to refine the design to insure operational acceptability.

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## SUMMARY

The Seating and Escape Branch (Code 6032) of the Aircraft and Crew Systems Technology Directorate is investigating the practicality of a "passive" arm restraint system designed for retrofit on Navy aircraft ejection seats. The term "passive" implies that the system will perform without the crewmember having to perform tasks other than those he currently performs (in a seat without an arm restraint system) to ready himself for flight. If the crewmember has to perform tasks specifically to ready a system, then the system is said to be an "active" system. The design under investigation is the Passive Arm Restraint Curtain (PARC).

The PARC prototype has been designed to be easily retrofitted on two Navy ejection seats; the GRU-7A seat which is in the F-14 aircraft, and the SJU-8/A seat which is to be used in A-7 and TA-7 aircraft.

The PARC is designed to meet the following requirements:

- Ease of installation on the ejection seat
- Low production cost
- No components attached to or routed on cockpit consoles, controls or canopy
- No adverse affect on current performance of the ejection seat system
- Must not hinder crewmember mobility or comfort during aircraft flight operations

## BACKGROUND

A common injury resulting from aircraft ejections is limb flail injury resulting from windblast affects. During the Vietnam conflict, serious flail injuries occurred in approximately 25 percent of all combat ejections.<sup>1</sup> Injuries to the limbs hamper the crewmember's attempt to control his parachute, to release his parachute after descent onto land and especially, into water, and to evade enemy ground forces.

Some ejection seats are equipped with leg garter systems which the crewmember must attach when he readies himself for flight (i.e., an "active" system). The leg garter systems help restrain the legs from flailing.

Current Navy aircraft ejection seats do not provide arm restraint systems. About two decades ago, an arm restraint was used by Navy crewmembers in the A-5 aircraft. The restraint consisted of arm sleeves that the crewmember had to don when he entered the cockpit. Connected to the sleeves were pull-straps which he had to attach. The donning and discomfort of this system was unacceptable to many crewmembers, therefore such a system was not used in other aircraft.

Along with the imposition of added tasks on the crewmember to ready an active system, there is the concern of improper attachment by the crewmember which will render the system useless or, worse yet, injure him. Also, the crewmember may ignore active tasks and not use the system at all.

By not having the crewmember perform more tasks to ready the arm restraint system, the Navy intends to acquire crewmember acceptance by developing a passive restraint.

Until the 1970's, Navy efforts to develop a passive arm restraint were very minimal if not non-existent. Then an effort was conducted to develop passive arm and leg restraint for the experimental Navy Maximum Performance Ejection Systems (MPES).<sup>2,3</sup> From that effort the Navy has learned what might be a practical approach to developing a retrofit passive arm restraint for Navy ejection seats.

## DESIGN APPROACH

The Passive Arm Restraint Curtain is designed to satisfy the requirements previously stated in the summary of this report. One other very important factor which influences the design is the deployment method required to retain the crewmember's arms. Because the crewmember's body is wider elbow-to-elbow than the seat is from side panel to side panel, a pull strap deployment of a restraint net along the side of the seat would be impractical since it would likely come under the crewmember's elbow and arm. To get around the elbow, the PARC has an attachment point at the torso harness/parachute riser connector fitting. When the crewmember enters the aircraft cockpit and attaches the appropriate fillings for restraining himself in the ejection seat, he will have readied the PARC. During flight the PARC remains slightly draped on the side of his shoulders. This configuration enables the curtain to move along the upper arm and around the elbow when the curtain is being deployed; yet, it does not restrict normal arm movement in the cockpit during aircraft flight operations.

Figures 1 and 2 show the PARC on the SJU-8/A ejection seat and GRU-7/A ejection seat, respectively. Components of the PARC are identical for both seats except for the attachment point location on the seat side panels.

The PARC consists of a curtain (a Kevlar fabric with a Raschel netting Knit), Nylon webbing slip rings, seat attachment fittings, webbing snubber mechanisms (the leg restraint snubber mechanisms are being used) and parachute riser attachments with breakaway straps.

The PARC is mounted along the sides of the ejection seat. The PARC seat attachment anchors one side of the curtain. Along the opposite side of the curtain the deployment webbing is attached. The webbing is routed from the inertia reel shoulder straps through seat cushion cover passageways to the snubber mechanisms at the lower front edge of the seat. The webbing is also attached to the parachute riser/torso harness connector fitting. The riser attachment has a breakaway strap which breaks during the seat/man separation event of the ejection.

During flight, the PARC remains slightly draped on the side of the crewmember's shoulders. See figure 3, 4, and 5. Elastic bands on the curtain netting gather up slack to prevent curtain interference with arm movement. For overall torso mobility, the curtain unfurls with crewmember shoulder excursion. See figures 6, 7 and 8. The slip ring attachment point at the upper end of the webbing allows the webbing to slide along the inertia reel straps as the crewmember leans forward and pulls out the inertia reel straps. This can be seen in figures 7 and 8.

The webbing is routed from the netting through detachable passageways in the seat lid cushion cover to the webbing snubber mechanism and then to a cockpit floor attachment. Ejection seat motion up the seat guide rails pulls the webbing through the seat cushion cover passageways and through the snubber mechanism. The curtain is pulled forward around the crewmember's arms. The snubber mechanisms keep the webbing and curtain tight around the arms after the webbing breaks away from the floor attachment. The PARC is designed for entrapping the arms for ejection initiated by the lower (seat pan) ejection handle or the upper (face curtain) ejection handle. Figure 9 through 13 show the deployment configurations for various ejection initiation modes with the GRU-7/A and SJU-8/A seats. To insure PARC deployment around the elbows, crewmembers should pull

the ejection initiation handles while bringing their elbows close to their torso. Figure 14 and 15 show the crewmember's arms forced into the curtain by windblast.

The PARC must not obstruct seat/man separation during ejection as the crewmember is being pulled out of the seat by his parachute. For seat/man separation, the inertia reel shoulder straps between the crewmember and seat are automatically separated; when this occurs the PARC falls away as the inertia reel straps slip through the PARC slip ring attachment. The parachute riser attachment breakaway strap also separates as the parachute begins to pull the crewmember out of the seat. The crewmember with his survival kit is then free to separate from the seat without being entangled in the PARC. Figure 16 shows a close-up view of the PARC breakaway attachment at the parachute riser connector fitting. Figure 17 shows the breakaway attachment about to separate and the slip ring which has slipped off the released inertia reel shoulder strap. Figure 18 shows the PARC which has fallen away from the crewmember after the breakaway attachment is separated by the parachute pull force. Figure 19 shows the crewmember with his survival kit being pulled free of the PARC and seat.

The seat lid cushion cover passageways stow the PARC webbing and position the webbing for proper deployment. The passageways rip apart either at the time of PARC deployment or at seat/man separation. This feature allows the survival kit to be pulled free of the PARC and seat.

#### TEST AND EVALUATION

The PARC has undergone preliminary testing and human factors evaluation. Semi-static tests were conducted on the NAVAIRDEVCON ejection tower facility to study the deployment of the PARC. A 98 percentile dummy simulating a sitting position for ejection initiated by the lower handle in a GRU-7A seat was used as the test configuration. The deployment webbing has a breakaway strength at the simulated cockpit floor attachment point of approximately 200 lb. For these tests the PARC deployed around the dummy's elbows.

Dynamic ejection tower tests with live subjects is the future goal. For these tests, PARC deployment for upper and lower handle ejections with various pull strap breakaway strengths would be investigated.

Hoist tests were conducted to study seat/man separation. In these investigations, live subjects (fully equipped with survival gear) were pulled from the seat to determine if the PARC would interfere with the subject or his survival kit. For both the GRU-7A seat and SJU-8/A seat there was no problem. However, it is recognized that ejection tests must still be conducted to verify that clean separation can be achieved.

A human factors evaluation was conducted with a test pilot (90 percentile sitting height) seated in a SJU-8/A seat equipped with the PARC. The seat was installed in an A-7 aircraft. A review of the pilot's cockpit tasks showed that the PARC did not hamper his mobility, nor was it uncomfortable. It was noted, however, that some attention should be given to the way the lower portion of the curtain is gathered-up; there is a possibility that the curtain may interfere with elbow movement when the pilot reaches for the rearward controls on the right-side instrument console. A slightly tighter take-up on the lower portion of the curtain may be required.

The PARC model was fabricated, primarily, for feasibility investigations regarding retrofittability, deployment practicality and human factors concerns. Although the netting and webbing materials of the PARC were selected to withstand windblast loads, the seat attachment points used during this phase of development were not structurally capable of withstanding windblast loads; therefore, windblast testing was not conducted.

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The leg restraint snubber mechanisms on the GRU-7/A and SJU-8/A seats were used to snub the deployment webbing of the PARC. The current leg restraint snubber mechanisms may be capable of performing the snubbing of both the leg restraint and arm restraint without having to be modified. For the PARC evaluations, each snubber mechanism snubbed two deployment straps — one for the leg restraint and one for the PARC.

## FUTURE EFFORTS

The PARC needs design refinement in the curtain packaging and webbing routing. The deployment pull force (200 lb. force was used in semi-static ejection tower tests) will also be investigated further to see if a higher pull force may help push the elbows in and allow the curtain to confine the crewmember's arms.

Future testing required for design verification must include dynamic ejection tests, windblast tests and high-speed ejection tests.

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2. Schwartz, M; Test and Evaluation of an Experimental Feasibility Prototype Passive Seat Mounted Limb Restraint System, Naval Air Development Center, NADC-81065-60, 20 May 1981, Warminster, PA.
3. Schwartz, M; Prototype Development Passive, Seat-Mounted Limb Retention System, Naval Air Development Center, NADC-79201-60, May 1979, Warminster, PA.

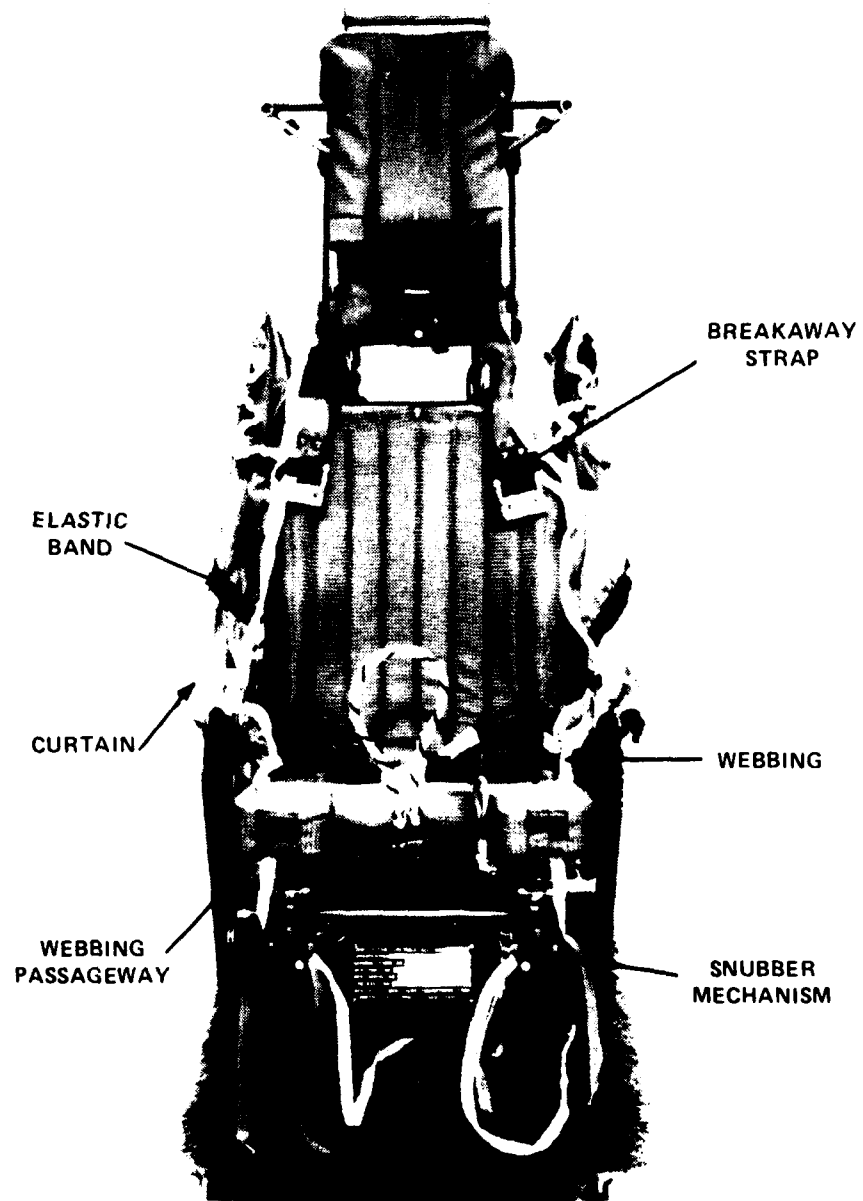


Figure 1. PARC on SJU-8/A Ejection Seat

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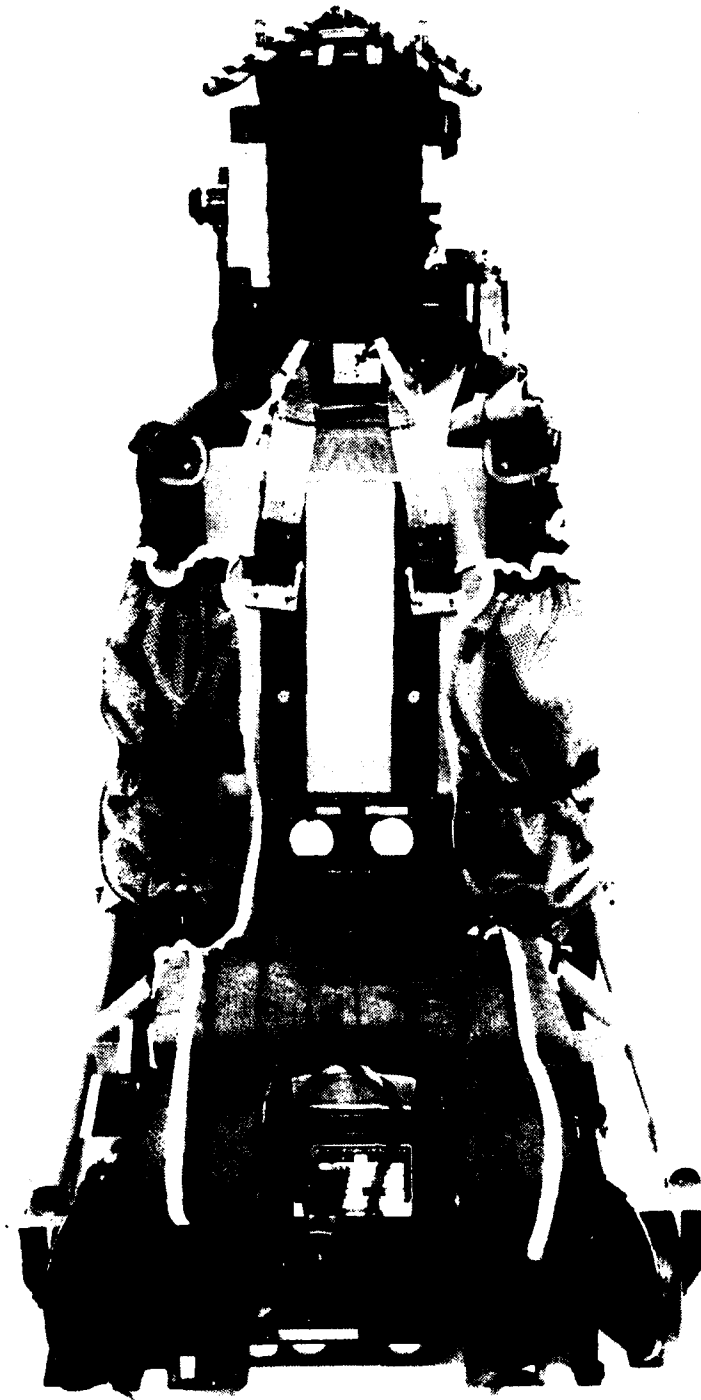


Figure 2. PARC on GRU-7/A Ejection Seat

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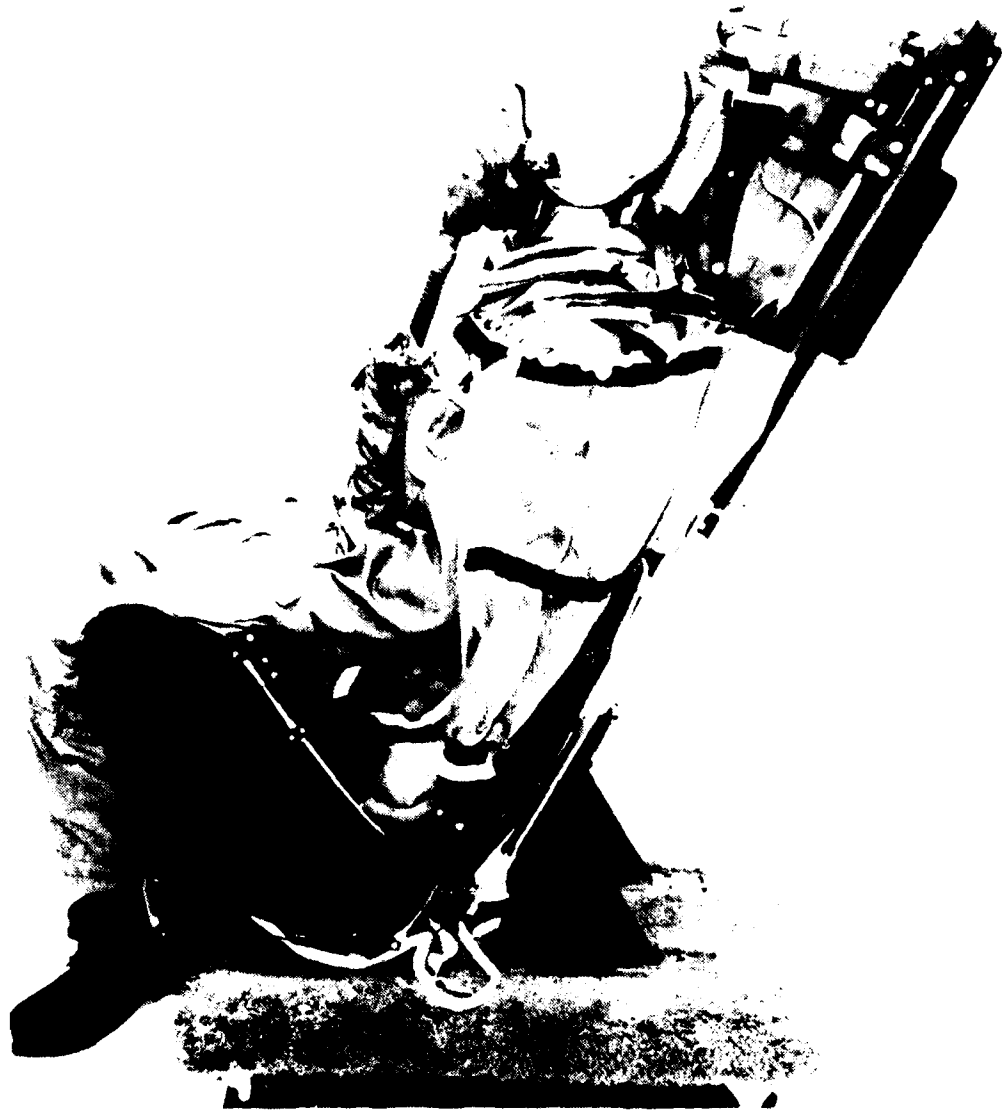


Figure 3. Sideview. Crewmember in Normal Sitting Position  
with PARC on SJU-8/A Seat

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Figure 4. Frontview. Crewmember in Normal Sitting Position  
with PARC on GRU-7/A Seat



Figure 5. Crewmember in Normal Sitting Position  
with PARC on GRU-7/A Seat



Figure 6. PARC Flexes as Crewmember Turns into Curtain  
SJU-8/A Seat

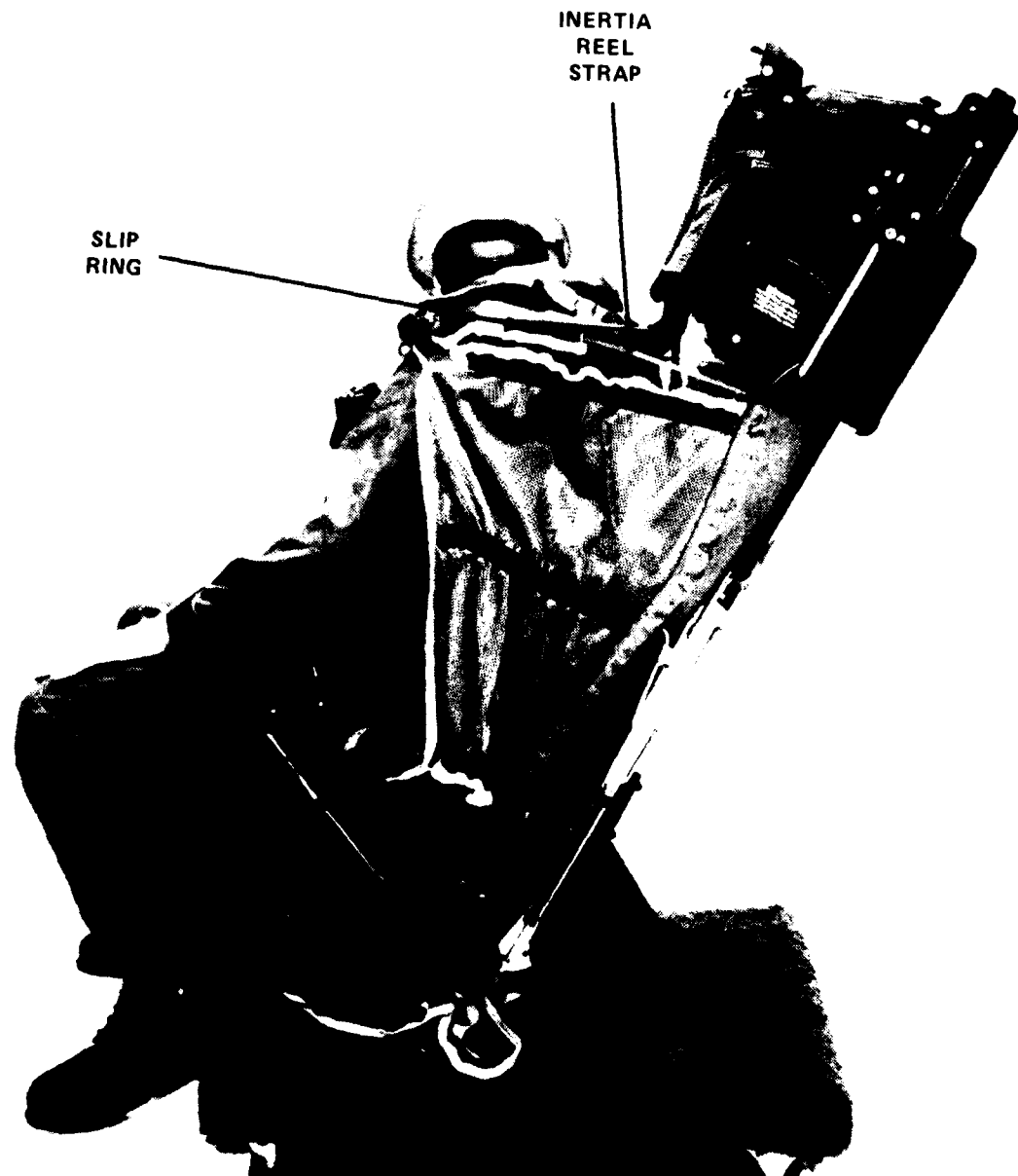


Figure 7. PARC Stretches as Crewmember Turns Away from Curtain. SJU-8/A Seat



Figure 8. PARC Stretches as Crewmember Moves Full Forward. GRU-7/A Seat



Figure 9. Frontview. PARC Deployed as Crewmember Pulls Lower Ejection Handle. SJU-8/A Seat

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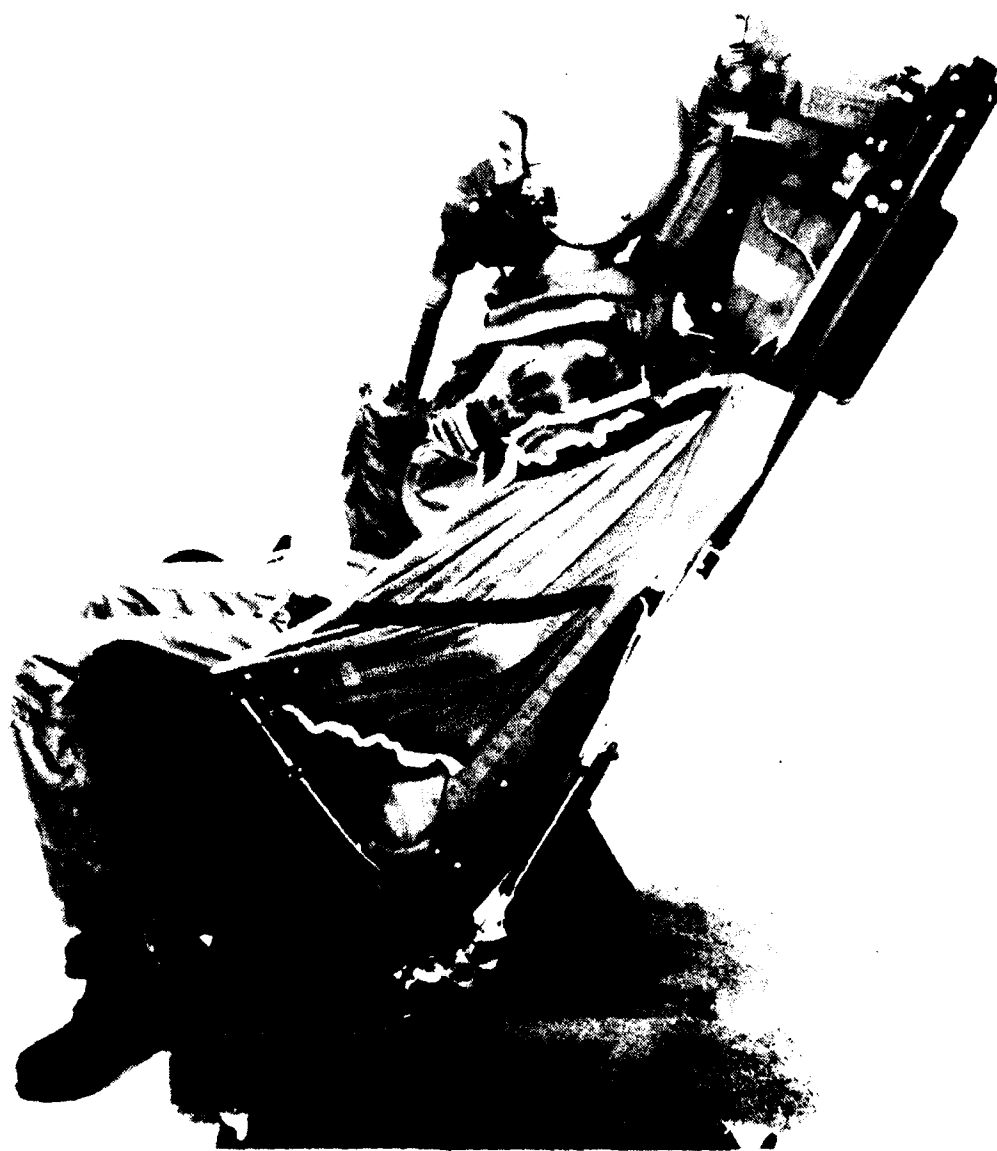


Figure 10. Sideview. PARC Deployed as Crewmember Pulls Lower Ejection Handle. SJU-8/A Seat



Figure 11. Frontview. PARC Deployed as Crewmember Pulls Lower Ejection Handle. GRU-7/A Seat



Figure 12. Sideview. PARC Deployed as Crewmember  
Pulls Lower Ejection Handle. GRU-7/A Seat

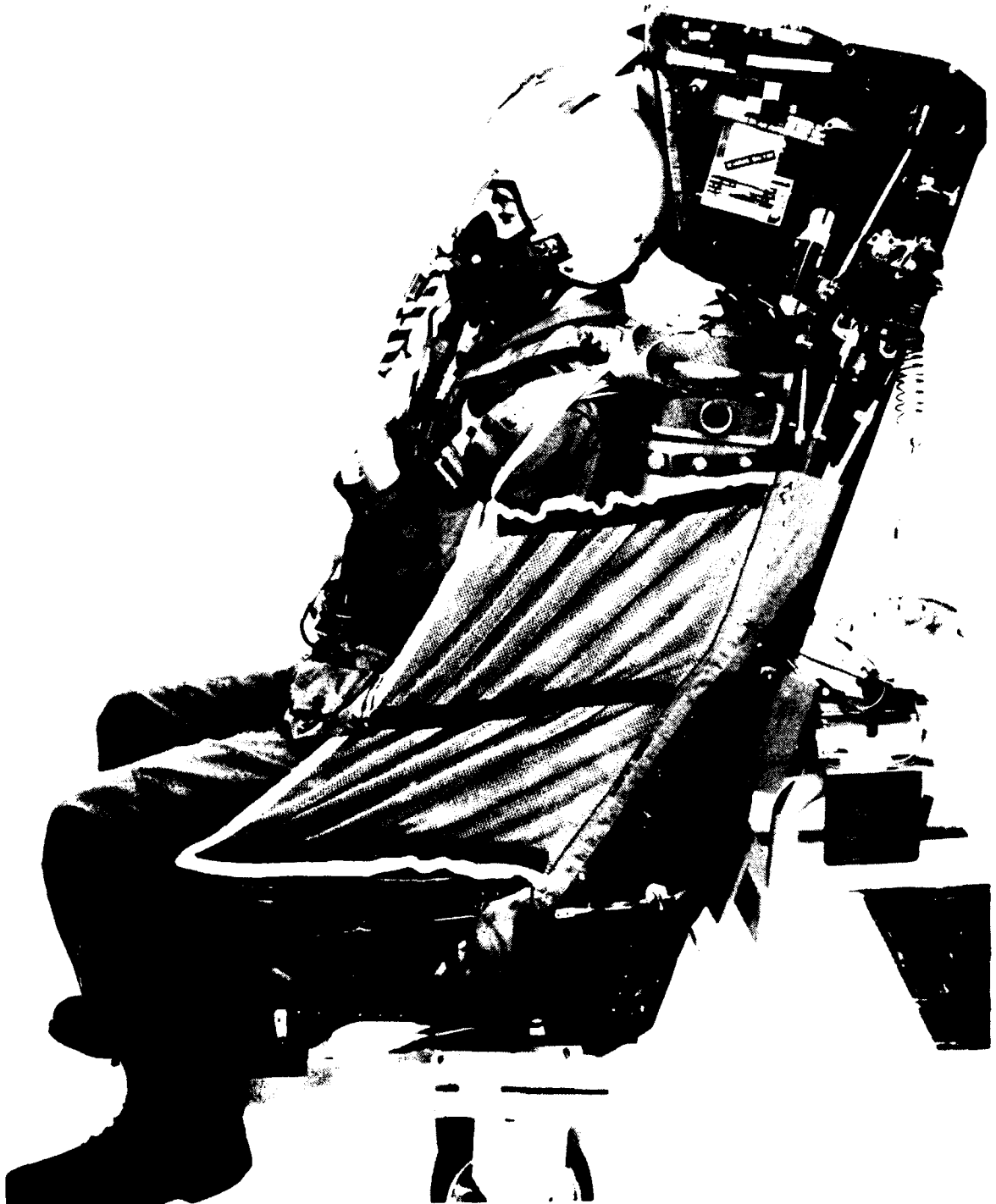


Figure 13. PARC Deployed as Crewmember Pulls  
Upper Ejection Handle. GRU-7/A Seat

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Figure 14. Crewmember's Arms Forced into Curtain  
SJU-8/A Seat



Figure 15. Crewmember's Arms Forced into Curtain  
GRU-7/A Seat



Figure 16. Breakaway Attachment at Parachute Riser  
Connector Fitting



Figure 17. Breakaway About to Occur as Parachute Begins to Pull Crewmember Out of Seat



Figure 18. Seat/Man Separation Begins.  
Crewmember is Free of PARC



Figure 19. Crewmember and His Survival Kit  
are Free of Seat

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